REMARKS

Applicant provides the following amendment along with a Request for Continued Examination. Claims 11, 23, 24, and 25 were previously amended to place them in better condition for appeal. Claims 11, 19 and 25 are currently amended. No new matter has been introduced by these amendments. Support for the amendments can be found in the specification and claims as originally filed. See page 4, lines 16 & 18, page 5, line 10, page 7, line5, page 8, and line 19 and original claim 8.

Rejection under 35 USC 112, first paragraph

The examiner has rejected Claims 11 and 25 under 35 U.S.C. §112, first paragraph as failing to comply with the written description requirement. The examiner states that Claims 11 and 25 the phrase "wherein said applying and heating introduce local ionic defects and increase lithium capacity of said metal oxide" is new matter and not described in the specification in such a way as to reasonably convey to one skilled in the art that the inventors, at the time the application was filed, had possession of the claimed invention.

Applicants respectfully disagree. Page 3, line 19 through page 4, line 5 of the application as filed provides "lithium-ion capacity of metal oxides may be controlled via point defects that may be introduced into a metal oxide by: (a) applying a mixture of O_2 and H_2O gas to a sufficient amount of a V_2O_5 metal oxide sample at a linear flow rate of about 50-350 ccm; (b) heating said metal oxide sample at a temperature of about 300-600 °C for a time period of about 6 – 72 hours; and cooling the metal oxide sample." Further, page 8, lines 11-16 of the specification as filed provide "Heating bulk V_2O_5 under O_2, O_2/H_2O, and AR causes no change in to the long-range structure of the metal oxide, but it significantly affects the V_2O_5 lithium capacity. Under the O_2, Ar, and Ar/H_2O heating steps, the Li capacity is decreased. The lithium capacity is increased for samples heated under O_2/H_2O. Since the long-range structure does not change, this suggests that *local ionic defects introduced by the O_2/H_2O heat treatment*, such as cation vacancies, are affecting the lithium capacity of the metal oxide." Further, FIG. 2 presents data that illustrates the effect of heating conditions under O_2, O_2/H_2O, Ar, and Ar/H_2O with regard to Li capacity. (See page 7, beginning on

line 11 for the discussion of Fig. 2). Applicants submit that these passages and the Figure meet the written description requirement of 35 U.S.C. §112, first paragraph, and respectfully request withdraw of this rejection and reconsideration of the claims in light of the claim limitation.

Rejection under 35 USC 112. second paragraph

The examiner has rejected Claim 11 as being indefinite because in claim 11 "said metal oxide sample" lacks proper antecedent basis in the claims. Applicants previously amended Claims 11, 23, 24 and 25 to remove the word "sample" to correct this error and place the claims in better condition for appeal. No new matter has been introduced by these amendments.

Rejection under 35 U.S.C. §103(a)

The examiner has rejected Claims 11, 17, 18, 23, and 24 under 35 U.S.C. §103(a) as being unpatentable over Thome '707 in view of either Nishihara '181 or the Chemical Principles reference to show statement of fact. The examiner states that "Tome suggests the process of heating a metal oxide, eg. V_2O_5 at 550 °C for about 8 hours in a flowing gas mixture of air and water vapor and cooling the metal oxide. The metal oxide appears to have the instantly claimed surface area; in any event the size of an article ordinarily is not a matter of invention. Air itself contains water vapor. ie. H_2O gas."

Applicants believe the current amendments overcome the examiner's rejection. The applicant has clarified that the heating step occurs under an atmosphere consisting essentially of O_2 and H_2O gas. These conditions were described in the specification on page 4, lines 16 & 18, page 5, line 10, page 7, line5, page 8, and line 19. The heating step is conducted under an O_2 and H_2O atmosphere.

Thome does not suggest the process of heating a metal oxide at 550 °C for about 8 hours in an atmosphere consisting essentially of O_2 and H_2O gas and cooling the metal oxide. Note that the O_2/H_2O of the present invention is not the same as the examiner's recited "gas mixture of air and water vapor". Air is not the O_2/H_2O atmosphere in the present claim. Air is approximately 79%

nitrogen and 21% oxygen (per the Chemical Principles reference), therefore would not be considered an "atmosphere of O_2/H_2O", as presently claimed. Heating the metal oxide at a low O_2 pressure would materially affect the basic and novel characteristics of the claimed invention. Additionally, the specification provides for the deleterious effects of heating the metal oxide at a low O_2 pressure (i.e. Ar and Ar/H_2O) as well as heating the metal oxide in an high O_2 pressure without the presence of $H_2O_{(g)}$.

Further, Thome discloses a method of producing a pure form of V_2O_5, from precursors, not a method of introducing defects in existing V_2O_5 or other metal oxides for the purpose of preparing a metal oxide for use as a battery cathode with increased capacity, as the presently claimed invention does. The final product of Thome is "bulk" V_2O_5, which is the precursor used in the examples of the presently claimed invention. The specification, as filed, page 5, lines 13-16, states: "To examine the interaction of Li^+ with defects in the V_2O_5 lattice, commercially available, anhydrous, bulk V_2O_5 is made defective by conventional heat treatments under O_2, O_2/H_2O, and Ar and Ar/H_2O, and the treated materials are tested for changes in the Li capacity relative to the as-received V_2O_5 powder." Thus, the present invention used, in an example, the final product of the method of Thome and further treats it by the present method to prepare a defective metal oxide having local ionic defects and increased lithium capacity.

Nishiara and/or the Chemical Principles does not supply what Thome lacks. The examiner has stated that the Nishihara reference provides that "air itself contains water vapor". Similarly, the Chemical Principles reference states that the composition of the atmosphere contains water vapor. As discussed above, air additionally contains approximately 79% nitrogen. Additionally, air contains other components that have been demonstrated in the present specification to decrease the specific capacity of the metal oxide. Specifically, the Chemical Principles reference provides that the atmosphere contains 18 specified components (plus water vapor and suspended particles). Those 18 components include O_2 and Ar (see chart in Chemical Principles reference). The specification as filed provides that the "specific capacities of the Ar-heated and O_2-heated V_2O_5 are 8% and 25% lower than that of the as-received V_2O_5, respectively." (see p. 7, lines 17-19 of the specification as originally filed.) Additionally, the specific capacity of the Ar/H_2O treated V_2O_5 was 58% lower

than the as-received V_2O_5. (seep p. 7, lines 14-16). Thus, heating a metal oxide in "air", which contains O_2 and Ar, as defined in either Nishihara and the Chemical Principles, cannot be expected to prepare a defective metal oxide having local ionic defects and increased lithium capacity. Thus, the present application teaches away from the use of "air", as air encompasses additional elements that lower the specific capacity of the treated metal oxide. Additionally, air is approximately 21% oxygen. Heating the metal oxide at a low O_2 pressure would materially affect the basic and novel characteristics of the claimed invention. Additionally, the specification provides for the deleterious effects of heating the metal oxide at a low O_2 pressure (i.e. Ar and Ar/H_2O) as well as heating the metal oxide in an high O_2 pressure without the presence of $H_2O_{(g)}$.

Additionally, on page 6, line 3, the present specification provides that after the heating in the atmosphere of O_2/H_2O and cooling process has been completed, the defective metal oxide that was prepared by this process was stored in sealed vials "under ambient air". Applicants respectfully submit that the atmospheric conditions of the heating step clearly occurs under a different atmospheric conditions than the storage conditions (ambient air). Thus the specification teaches against heating in "air".

Applicants submit that the examiner's rejection has been overcome and respectfully request reconsideration.

Rejection under 35 U.S.C. §103(a)

Claims 11 and 24 were rejected under 35 USC §103(a) as being unpatentable over Howard '477 in view of either Nishihara '181 or the Chemical Principles reference. The examiner states Howard suggests "the process of heating a metal oxide sample, eg, $LiMn_2O_4$, in flowing air at the instantly claimed flow rate. Air contains water vapor or H_2O gas according to Nishihara and the Chemical Principles reference. The metal oxide appears to have the instantly claimed surface area: in any event the size of an article ordinarily is not a matter of invention."

Applicants believe the current amendments overcome the examiner's rejection. The applicant has clarified that the heating step occurs under an atmosphere consisting essentially of O_2

and H_2O. These conditions were described in the specification on page 4, lines 16 & 18, page 5, line 10, page 7, line5, page 8, and line 19.

Howard does not suggest the process of heating a metal oxide at 550 °C for about 8 hours in an atmosphere consisting essentially of O_2/H_2O and cooling the metal oxide. Note that the O_2/H_2O of the present invention is not the same as the examiner's recited "gas mixture of air and water vapor". Air is not the atmosphere consisting essentially of O_2/H_2O in the present claim. Air is approximately 79% nitrogen and 21% oxygen (per the Chemical Principles reference), therefore would not be considered an "atmosphere consisting essentially of O_2/H_2O", as presently claimed. Heating the metal oxide at a low O_2 pressure would materially affect the basic and novel characteristics of the claimed invention. The specification provides for the deleterious effects of heating the metal oxide at a low O_2 pressure (i.e. Ar and Ar/H_2O) as well as heating the metal oxide in an high O_2 pressure without the presence of $H_2O_{(g)}$.

Further, Howard does not teach or disclose a the present method to prepare a defective metal oxide having local ionic defects and increased lithium capacity. Howard teaches an intercalation composition and a method for making such. An intercalation composition is one where a molecule (or group) is included between two other molecules (or groups). The host usually has some periodic network. Howard teaches the use of a spinel structure and the molecule included is a trivalent metal cation that adapts to the spinel structure in place of manganese. (see col 3 line 57 – col. 4 line 23). The method Howard discloses is a method that starts with precursors and ends up with a different composition. Howard teaches "lithium manganese oxide intercalation compositions of the above formula are basically comprised of intimately mixing particulate solid reactants comprised of lithium, manganese and one or more of the above described trivalent metals in the form of oxides, thermally decomposable salts or mixtures thereof in amounts based on the above formula. The resulting intimately mixed reactants are introduced into a reactor, and the mixed reactants are heated in the reactor, preferably while continuously being agitated, in the presence of air or an oxygen enriched atmosphere at a temperature in the range of from about 550 °C to about 850 °C for a time period of up to about 48 hours. Thereafter, the reacted product formed is gradually cooled to a temperature of less than about 500 C°." (See Col. 3, lines 1-15). The trivalent metals are

aluminum, chromium, gallium, indium and scandium. (See Col. 2, lines 64-67). Thus the starting materials, which are heated, do include a metal oxide, however, the final product has a different chemical composition after the heating step. The present invention starts with a metal oxide, does not add any other starting material, and the heating step in performed in an atmosphere consisting essentially of O_2/H_2O, and the final product has the same long-range structure but also having local ionic defects and increased lithium capacity. Page 7, lines 1-10 of the specification as filed provides "X-ray diffraction shows that the as-received, orange-colored V_2O_5 is crystalline and has the Shcherbinaite structures. The same phase is measured for the samples heated at 460 °C under O_2, O_2/H_2O, and Ar (Fig. 1), indicating that the long-range structure of the V_2O_5 is not affected by these temperature/atmosphere/time conditions and suggesting that ionic defects have been introduced."

Thus, the present application teaches away from the use of "air" or an "oxygen enriched atmosphere", as air encompasses additional elements that lower the specific capacity of the treated metal oxide. Additionally, an O_2-only atmosphere actually decreases the specific capacity of the defective metal oxide.

Additionally, Nishiara and/or the Chemical Principles does not supply what Howard lacks. The examiner has stated that the Nishihara reference provides that "air itself contains water vapor. Similarly, the Chemical Principles reference states that the composition of the atmosphere contains water vapor". As discussed above, air additionally contains approximately 79% nitrogen. Additionally, air contains other components that have been demonstrated in the present specification to <u>decrease</u> the specific capacity of the metal oxide. Specifically, the Chemical Principles reference provides that the atmosphere contains 18 specified components (plus water vapor and suspended particles). Those 18 components include O_2 and Ar (see chart in Chemical Principles reference). Note that the present application provides that the "specific capacities of the Ar-heated and O_2-heated V_2O_5 are 8% and 25% lower than that of the as-received V_2O_5, respectively." (see p. 7, lines 17-19 of the specification as originally filed.) Thus, heating a metal oxide in "air", which contains O_2 and Ar, as defined in either Nishihara and the Chemical Principles, would not be reasonably expected to produce the defective metal oxide with increased capacity having local ionic defects

produced by heating the metal oxide in "atmosphere consisting essentially of O_2/H_2O" as claimed in the present application.

Additionally, on page 6, line 3, the present specification provides that after the heating in the atmosphere of O_2/H_2O and cooling process has been completed, the defective metal oxide that was prepared by this process was stored in sealed vials "under ambient air". Applicants respectfully submit that the atmospheric conditions of the heating step clearly occurs under a different atmospheric conditions than the storage conditions (ambient air). Thus the specification teaches against heating in "air".

Applicants submit that the examiner's rejection has been overcome and respectfully request reconsideration.

Rejection under 35 U.S.C. §103(a)

Claims 11, 17, 18, 19, 23, 24and 25 have been rejected under 35 U.S.C. 103(a) as being unpatentable over Chambers '005. The examiner states that "Chambers suggests the process of heating a sample of V_2O_5 at 500° C in a stream of air saturated with water vapor, ie., flowing gas mixture of O_2 and H_2O. See Col. 4, and example 1."

Applicants believe the current amendments overcome the examiner's rejection. The applicant has clarified that the heating step occurs under an atmosphere consisting essentially of O_2 and H_2O. These conditions were described in the specification on page 4, lines 16 & 18, page 5, line 10, page 7, line5, page 8, and line 19. The heating step is conducted under an O_2 and H_2O atmosphere.

Chambers does not suggest the process of heating a metal oxide at 550 °C for about 8 hours in atmosphere consisting essentially of O_2 and H_2O and cooling the metal oxide. Note that the O_2/H_2O of the present invention is not the same as the recited "gas mixture of air and water vapor". Air is approximately 79% nitrogen and 21% oxygen (per the Chemical Principles reference).

therefore would not be considered an atmosphere consisting essentially of O_2/H_2O, as presently claimed. Heating the metal oxide at a low O_2 pressure would materially affect the basic and novel characteristics of the claimed invention. The specification provides for the deleterious effects of heating the metal oxide at a low O_2 pressure (i.e. Ar and Ar/H_2O) as well as heating the metal oxide in an high O_2 pressure without the presence of $H_2O_{(g)}$.

Additionally, the Chambers teaches a method of separating vanadium from vanadium bearing material. Chambers teaches the use of raw material, such as "titanium slag" (see example 1) and extracting from it pure vanadium. Chambers neither teaches nor discloses a method to prepare a defective metal oxide having local ionic defects and increased lithium capacity as presently claimed. Chambers applies heat to vanadium precursors (slag) that is exposed to air and water vapor at an elevated temperature, wherein the vanadium present in the slag volatizes in the form of the hydroxide and that hydroxide decomposes upon cooling to a mixture of water vapor and vanadium oxide. The vanadium oxide product of Chambers is equivalent to the bulk vanadium oxide starting material of the present specification. Chambers does not teach or disclose a method to prepare a defective metal oxide having increased capacity and local ionic defects, as claimed in the present invention.

Additionally, Nishiara and/or the Chemical Principles does not supply what Chambers lacks. The examiner has stated that the Nishihara reference provides that "air itself contains water vapor. Similarly, the Chemical Principles reference states that the composition of the atmosphere contains water vapor". As discussed above, air additionally contains approximately 79% nitrogen. Air contains other components that have been demonstrated in the present specification to decrease the specific capacity of the metal oxide. Specifically, the Chemical Principles reference provides that the atmosphere contains 18 specified components (plus water vapor and suspended particles). Those 18 components include O_2 and Ar (see chart in Chemical Principles reference). Note that the present application provides that the "specific capacities of the Ar-heated and O_2-heated V_2O_5 are

8% and 25% lower than that of the as-received V_2O_5, respectively." (see p. 7, lines 17-19 of the specification as originally filed.) Thus, heating a metal oxide in "air", which contains O_2 and Ar, as defined in either Nishihara and the Chemical Principles, would not be reasonably expected to produce the defective metal oxide with increased capacity having local ionic defects produced by heating the metal oxide in "O_2/H_2O" as claimed in the present application.

Additionally, on page 6, line 3, the present specification provides that after the heating in the atmosphere of O_2/H_2O and cooling process has been completed, the defective metal oxide that was prepared by this process was stored in sealed vials "under ambient air". Applicants respectfully submit that the atmospheric conditions of the heating step clearly occurs under a different atmospheric conditions than the storage conditions (ambient air). Thus the specification teaches against heating in "air".

Applicants submit that the examiner's rejection has been overcome and respectfully request reconsideration.

Rejection under 35 U.S.C. §103(a)

The examiner has rejected claims 11, 17, 18, 20-22 and 24 under 35 U.S.C. 103(a) as being unpatentable over Shizuka '637 in view of either Nishihara '181 or the Chemical Principles reference. The examiner stated "Shizuka suggests the process of heating a metal oxide, e.g. Mn_2O_3, Co_3O_4, in air to 500°C for 6 hours at a rate of 5°C/min and then cooling the metal oxide to room temperature, ie. ambient, at a rate of 5°C/min. [...] See examples 1-5, 8. Air contains water vapor, ie. H_2O gas. See Nishihara, Col. 2, line 23 and the Chemical Principles reference.

Applicants believe the current amendments overcome the examiner's rejection. The applicant has clarified that the heating step occurs under an atmosphere consisting essentially of O_2 and H_2O. These conditions were described in the specification on page 4, lines 16 & 18, page 5, line 10, page 7, line5, page 8, and line 19. The heating step is conducted under an atmosphere consisting essentially of O_2 and H_2O.

Shizuka does not suggest the process of heating a metal oxide at 550 °C for about 8 hours in an atmosphere consisting essentially of O_2 and H_2O and cooling the metal oxide. Note that the O_2/H_2O of the present invention is not the same as the recited "gas mixture of air and water vapor". Air, as discussed below in more detail, is not the atmosphere consisting essentially of O_2 and H_2O in the present claim. Air is approximately 79% nitrogen and 21% oxygen (per the Chemical Principles reference), therefore would not be considered an atmosphere consisting essentially of O_2/H_2O, as presently claimed. Heating the metal oxide at a low O_2 pressure would materially affect the basic and novel characteristics of the claimed invention. The specification provides for the deleterious effects of heating the metal oxide at a low O_2 pressure (i.e. Ar and Ar/H_2O) as well as heating the metal oxide in an high O_2 pressure without the presence of $H_2O_{(g)}$.

Further, Shizuka does not teach or disclose a method to prepare a defective metal oxide having increased capacity and local ionic defects, as claimed in the present invention. Shizuka introduces a molecule into a spinel structure. All of Shizuka's examples include several starting materials that are blended. The metal oxide is one of the several starting materials (see col. 6, line 41, and examples). The starting materials are blended and calcined to create a new material with a different chemical composition than any of the starting materials. No mention of a defective metal oxide having increased capacity and local ionic defects is made. Additionally, the firing process of Shizuka is carried out in "air or an oxygen atmosphere" (Col. 7, line 14), followed by an annealing process carried out in an "oxygen atmosphere" (Col. 7, line 15-16) (see examples 1-5, 8 Thus, the present specification teaches away from the disclosure of Shizuka, in that neither "air" nor an "oxygen atmosphere" will produce the local ionic defects of the present invention.

Nishiara and/or the Chemical Principles does not supply what Shizuka lacks. The examiner has stated that the "Nishihara reference provides that "air itself contains water vapor". Similarly, the Chemical Principles reference states that the composition of the atmosphere contains water vapor". While the air itself does contain water vapor, it also contains other components that have been demonstrated in the present specification to decrease the specific capacity of the metal oxide. Specifically, the Chemical Principles reference provides that the atmosphere contains 18 specified components (plus water vapor and suspended particles). Those 18 components include O_2 and Ar

(see chart in Chemical Principles reference). Note that the present application provides that the "specific capacities of the Ar-heated and O_2-heated V_2O_5 are 8% and 25% lower than that of the as-received V_2O_5, respectively." (see p. 7, lines 17-19 of the specification as originally filed.) Thus, heating a metal oxide in "air", which contains O_2 and Ar, as defined in either Nishihara and the Chemical Principles, would not be reasonably expected to produce the defective metal oxide with increased capacity having local ionic defects produced by heating the metal oxide in "O_2/H_2O" as claimed in the present application.

Additionally, on page 6, line 3, the present specification provides that after the heating in the atmosphere of O_2/H_2O and cooling process has been completed, the defective metal oxide that was prepared by this process was stored in sealed vials "under ambient air". Applicants respectfully submit that the atmospheric conditions of the heating step clearly occurs under a different atmospheric conditions than the storage conditions (ambient air). Thus the specification teaches against heating in "air".

Applicants submit that the examiner's rejection has been overcome and respectfully request reconsideration.

Additional Remarks/Arguments

In further support for the claims, Applicants submit an article, published by the two inventors and a research assistant, "Improved lithium capacity of defective V_2O_5 materials", Solid State Ionics 152-152 (2002) 99-104 (accepted 14 February 2002). The article provides that "at high oxygen pressures in the presence of water vapor , cation vacancies are stabilized in the lattice" (see p. 100, col. 2, beginning directly below Equation 8). Further, the article provides that "...heating under O_2 plus H_2O (O_2/H_2O) will create cation vacancies associated with hydroxyl groups (Eq. (9). Heating under low oxygen pressures (i.e. Ar) creates V4+ sites and anion vacancies (Eq. (2)) and heating under Ar plus H_2O (Ar/H_2O) environment created v4+ defects and hydroxyl groups in the lattice (Eq. (8))." (see p. 101, col. 1, lines 7- 13). This article and its equations are provided to

support that fact that low O_2 pressures (such as those found in air) will not achieve the claimed local ionic defects that increase Li-ion capacity in the metal oxides. Heating the metal oxide at a low O_2 pressure would materially affect the basic and novel characteristics of the claimed invention. Additionally, as discussed above, the specification provides for the deleterious effects of heating the metal oxide at a low O_2 pressure (i.e. Ar and Ar/H_2O) as well as heating the metal oxide in an high O_2 pressure without the presence of H_2O).

In view of the above amendment and remarks, applicant believes the pending application is in condition for allowance.

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